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Suitability of Indiana Coal as a Locomotive Fuel

By

J. E. BJORKHOLM

**Ass't Superintendent Motive Power
C., M., St. P. and P. Ry. Company, Milwaukee, Wis.**

**A Paper Presented at the Second Indiana Fuel Conference
Held at Purdue University, Lafayette, Indiana,
April 4, 5, 1929**



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(A paper presented at the Second Indiana Fuel Conference held at Purdue University, Lafayette, Ind., April 4, 5, 1929.)

The subject of Indiana coal as a locomotive fuel is one that should be of particular interest to this conference because of the abundant supply of bituminous coal available within the State and the large railroad mileage within what may be termed an economical hauling distance from the source of supply, thus creating a large potential market for it. In dealing with the subject I have purposely omitted questions of a technical nature, confining myself to the practical side, aiming to approach the matter from the point of everyday practice with our steam locomotives.

In considering the question of a desirable locomotive fuel it is necessary that the factors surrounding locomotive operation, the present demands placed on the steam locomotive, and the policy of future improvements of the service be given considerable thought; and I trust you will pardon me if, in presenting this paper, I have gone to some length in trying to picture conditions incident to present-day steam locomotive operation, as these have a direct bearing on what does and what does not constitute a satisfactory locomotive fuel. These are conditions that must be seriously considered in selecting a fuel that will both render good service and be economical as well.

It is well known that, next to wages, the item of fuel is the largest single item of expense confronting the American railroads. In the past very little attention was paid to the matter of fuel economy, it being left largely to take care of itself. Coal was abundant and cheap, and as long as the locomotive fireman was able to furnish the required amount

of steam little was thought as to whether the fireman or the locomotive or both were wasting fuel. So long as the steam pressure was available and the fireman was able to satisfy the appetite of the firebox, everybody was happy.

In later years, however, largely due to the splendid efforts of such organizations as the International Railway Fuel Association and the Traveling Engineers Association in pointing out the possibilities of handsome savings in the operation of railroads, through the medium of economy, instead of waste, in the handling of railway fuel, an enthusiasm in fuel economy has been awakened among the railroad managements; an enthusiasm that today, on every well managed property, is constantly stimulated among officers as well as line employees, with the result that economy in fuel is looked upon as one of the most important items in railroad operation.

In selecting coal for locomotive fuel the important questions to be considered are: the price at the mine, the distance from the mine or point of distribution to the point of consumption, and the quality of the coal.

In considering the quality the chemical properties of the coal, important as they are, by no means constitute the only factor to be taken into consideration. The preparation of the coal is another important factor that must play a part in the selection of a desirable locomotive fuel. The importance of this item can not be overemphasized. Only too frequently a coal having all the properties that go to make a desirable locomotive fuel is rendered undesirable by carelessness instead of care having been used in its preparation and loading at the mine.

The steam locomotive is at its best a power plant subjected to more abuses and greater fluctuation in load demand than any other power plant in existence. While even the most modern locomotives are wasteful in the extreme when we consider the very low percentage of energy liberated from the coal actually performing useful work, they are monuments of efficiency compared with the older types designed and built some fifteen or twenty years ago, of which there still are many in service. Particularly when engines of an early design built to meet conditions of an earlier period are required to perform in competition with more modern locomotives a coal well adapted as a locomotive fuel is essential if prompt

and uninterrupted service is to be maintained, and this is especially true when these engines have been assigned to runs, the distance of which was not only unheard of but unthought of when they were designed.

It is frequently stated that the selection of a high standard locomotive fuel is not as essential today as it was, say, fifteen or twenty years ago, when, as a general rule, the locomotives were not as well designed as they are today, and when many of the present-day fuel saving devices had not as yet been introduced. Generally this may be true; but even though the modern locomotive is a better proportioned machine in all respects we must not overlook the very important fact that the service required of the locomotive of today is far in excess of that demanded a few years ago. Further, it is not only of the very modern locomotive that a higher standard of service is demanded. The engine designed and built two decades ago frequently must compete with modern engines; and if we are to operate them on a basis measured by present-day aims and standards, then I say, and I say most emphatically, that greater care in the selection of a satisfactory locomotive fuel is necessary today than it was when they were built.

Until recently the length of a locomotive run was usually measured by the distance run by the engine crew, and as a rule did not exceed 200 miles, while in most cases 100 miles was the established run. After covering a run the locomotive had the firebox cleaned, the ashpan emptied, and the grates and flues inspected and cleaned before a fire was again built. Under these conditions the proper preparation of the fuel was not as essential as it is today. Today these same engines are run on a faster schedule and pull heavier trains several times the distance run a few years ago. We all know that the difficulties with coal-burning locomotives multiply rapidly as the distance run increases, principally because of the accumulation of ash and clinkers in the firebox plus what is commonly termed the formation of honeycomb in flues and on the flue sheet. The latter is particularly annoying, as this formation at times will completely block the flue openings, thus interfering seriously with the steaming of the boiler. This so-called honeycomb is the result of the slack and fine particles in the coal becoming plastic at a high temperature

and gradually building up a condition that at times may be responsible for complete steam failures with attendant disruption of traffic.

While on the subject of extended locomotive runs, permit me to venture the opinion that, while American railroads have made considerable progress in this respect in the past few years, this is a movement that as yet is only in its infancy. With the locomotive designer considering the necessity of extended runs as a factor of major importance and thus building locomotives well adapted for this kind of service, I feel satisfied that where operating conditions permit runs of 800 to 1,000 miles will, in the near future, be the rule instead of the exception. Because of the efforts by the railroads to speed up traffic the firebox temperature as a rule is higher today than formerly, as the locomotives are being worked to a greater capacity. The difficulties just mentioned increase with the increase of the firebox temperature, and it is evident that a locomotive fuel must be selected with greater care today than formerly. To carry out such a program of extended runs and intensified running conditions successfully it becomes a matter of great importance that the coal be given exceptional care in preparation to prevent too much incom-bustible material finding its way into the coal and thence to the locomotive, because the firebox must of necessity be restricted in size and a full firebox and a well steaming locomotive are two factors as widely separated as the poles.

Our passenger engines in certain districts where we are burning Indiana coal operate on continuous runs of 350 miles, and we are contemplating increasing this by running over an additional division which will make runs approximately 500 miles in length.

Our freight engines in similar districts are operating on some divisions over 315 miles of continuous runs and, like the passenger engines, are burning Indiana coal. No trouble has ever been experienced due to lack of steam, except in a few instances where we were using run of mine coal containing a high percentage of fine. This caused so-called honeycomb formations to be plastered over the flue sheets in such quantities that the flue openings were almost entirely blocked. The fact that we are operating these engines successfully and with what I consider a reasonable fuel consumption, when the serv-

ice characteristics are considered, is in itself a very favorable recommendation for Indiana coal.

It may be of interest to mention that, as a matter of exhibit, we have run a 4-6-2 Pacific type passenger locomotive, built fifteen years ago and burning Indiana coal, on one of our trans-continental passenger trains consisting of fourteen steel cars, a distance of 800 miles without detaching the engine from the train. I am mentioning this because it has been generally considered that on runs of this length a coal having less clinker-forming ash than ordinarily found in Indiana coal would be required.

The ideal coal for locomotive fuel is a coal that is neither all lumps nor all fine. It is true that an ideal condition is seldom to be found in any of our undertakings, and this holds true in the matter of fuel. Good mine run coal as an efficient locomotive fuel compares favorably with coal of a more selective specification, but good mine run is a scarce article and seldom found. Only too frequently too much incombustible matter is permitted in run-of-mine coal. Also, since even good run-of-mine coal as obtained from the Indiana fields usually contains at least 40 per cent fine at the mine and so considerably more by the time it has been unloaded into the coaling stations and thence onto the locomotive tenders, the percentage of fine is usually too much for an efficient locomotive fuel. Stack losses and ashpan losses alone with a fuel of this character are considerable; and, as previously mentioned, there may occur, particularly where a high firebox temperature obtains, slagging of flue and crown sheet and other parts of the heating surface of the boiler as well as ash and clinker formation on the grates, all of which result in an excessive fuel consumption, leaky flues, added maintenance cost, and traffic delays. These traffic delays are sometimes very costly. For instance, on a train of live stock an hour's delay en route may mean the necessity of feeding and resting the stock at some intermediate station, resulting in perhaps a day's delay; and in the meantime the market may have declined and the railroad have an expensive claim to settle. Also, it frequently happens that a delay to an important passenger train results in the passengers missing important connections, with much consequent embarrassment and inconvenience.

Stoker-fired locomotives increase year after year and the

absence of foreign matter such as slate, bone, and other impurities is absolutely necessary in a coal used as stoker fuel; otherwise stoker failure is likely, usually accompanied by an engine delay.

A good deal has been said from time to time as to what constitutes the most practicable locomotive fuel. It is a question that in my opinion can not be decided unless the various conditions under which the fuel is to be used are taken into consideration. Thus, a fuel entirely satisfactory for locomotives engaged in switching service or short-run passenger or freight service may be neither satisfactory from a fuel standpoint nor from an economical standpoint when an altogether different kind of service is desired.

The price F. O. B. point of distribution is not the only governing factor establishing whether a fuel is economical or not. Cost of firebox cleaning, cost of flue boring, delays en route due to lack of steam or to fire and ashpan cleaning, damaged grate, usually the result of a badly clinkered fire, etc., are factors that should be considered even though the price per unit per measure of consumption may appear favorable.

The opinion, I believe, is generally accepted that a coal three or four inches in size and with a mixture of not more than 30 per cent fine coal under one inch is an ideal fuel for locomotive use. It permits a firebed through which the air needed for combustion may flow freely and at the same time a sufficient amount of fine coal to guard against air holes in the firebed. It is understood of course that this has reference to coal similar in nature to that mined in Indiana. When a coal with cooking characteristics is burnt a larger percentage of fine can be burnt quite efficiently.

It is a notable fact that the railroads in later years have made exceptional progress in handling an ever-increasing volume of traffic, and this has been accomplished at no small cost. As rate increases have not kept step with necessary expenditures the railroads have been able to do this only through the most efficient housekeeping methods, and in these the proper selection of fuel with resultant economy is one of the most important factors. The American public demands speed and on-time performance, be it a matter of personal travel or a matter of a carload of merchandise. Speed induced by a steam locomotive would not be possible were it not

for the energy liberated from the coal, and the amount of energy liberated depends largely on the quality of the preparation of the fuel. Slate, bone, under-cuttings, clay, or any other of the various impurities so frequently found in the coal does not liberate energy; instead, it liberates trouble and sometimes trouble of very far-reaching consequences. A modern locomotive is a wonderful machine, but this machine, particularly on a cold winter day, is the most helpless thing on earth if the boiler is unable to furnish the necessary steam pressure. To insure a high grade transportation it therefore becomes a very important matter that the utmost care be exercised at the mines in so preparing the coal that, barring mechanical breakdowns, the locomotive will function as intended.

In the economical burning of fuel the firebox grate plays a very important part; and a grate designed merely for the purpose of insuring a clean firebox so that the engine may complete its run successfully, regardless of the quality of the coal or the way the fireman performs his work, is oftentimes most wasteful. It was designed along the lines of least resistance, but not with much reference to economy. Today a good deal of thought is given to the grate that combines the features of serviceability and economy.

Grate losses, due to the coal falling through the grate and into the ashpan at the time the fire is being built and when the grates are perfectly clean, constitute no small loss on a large railroad. For instance, on a railroad similar to the one with which I am associated, something like 1,000 engines are fired up daily, and as the grate losses through the old standard box grates averaged four scoops of coal per engine, the average scoopful containing fifteen pounds of coal, the daily loss was approximately thirty tons of coal a day, or 11,000 tons in a year. With this condition confronting us considerable thought is being given to securing a more economical grate, a grate that may demand a little more care on the part of the fireman but which will prove economical. However, such a one will not permit so much incombustible matter being shaken down into the ashpan as in the old grate, so a cleaner coal must be used for successful operation.

During the year 1928 we burned on the Milwaukee Road approximately 3,790,000 tons of coal, of which about 2,700,000

tons came from the Indiana fields. It thus appears that Indiana furnished the most of the coal used in our locomotives. The next largest producer was the Roundup (Montana) Field, from which we obtain a coal that is a very satisfactory locomotive fuel, a fuel that is high in carbon, very low in sulphur, and with an ash that is not clinker forming, and that, as a result, lends itself favorably to long distance runs. It contains a high percentage of moisture, however, and therefore disintegrates badly when exposed to the weather, which is an unfavorable factor. It is a light coal, and the utmost care is required to reduce the fire hazard to a minimum. The stack losses from this coal are greater than from the Indiana coal, and if proper care is not taken in firing, the front end netting clogs very readily, usually causing a delay due to steam failure.

A limited amount of Iowa coal is also used. This coal has a lower B. T. U. value than either the Indiana or Roundup coal, and is also higher in ash and moisture. The ash in this coal forms a clinker that differs from that of Indiana coal. The clinker from Iowa coal, particularly when the locomotive is being worked to capacity with a high firebox temperature, is in the nature of a molten mass, clogging the grate openings and frequently resulting in trouble for steam.

A small quantity of our locomotive fuel is also obtained from Duluth dock, this coal usually originating in West Virginia. It is a high grade fuel, but from an economical standpoint can only be used advantageously in the territory we operate where the haul from the point of loading is a comparatively short one.

The question of storage is one that is of considerable importance. The Indiana coal, we have found, can be stored quite successfully in large quantities when ordinary care is exercised. Thus we stored, some two years ago, approximately 325,000 tons, a large part of which remained under storage for a period of one and one-half years without experiencing any trouble from heating and very little loss from disintegration.

Nature has been very kind to the Hoosier State in depositing such vast amounts of mineral wealth within its borders. With the coal fields so located that a great railroad mileage is within easy reach, there is a great opportunity to create

a vast market for Indiana coal, a large part of which is suitable as a locomotive fuel. Although for locomotive purposes coal from certain seams has advantages over that from others, as a general rule the coal is well adapted for locomotive use. It is an old saying that "the proof of the pudding is in the eating." So, after having had experience with the burning of Indiana coal as a locomotive fireman and as a locomotive engineer, as well as in a supervisory capacity, for many years, I can say this coal can be used to good advantage in any kind of locomotive service and will prove satisfactory both in service and in economy. It is fairly quick to ignite, a very important factor as, with ordinary care in firing, a well burning fire will result almost immediately after the coal has been added and the fire door closed.

A satisfactory locomotive fuel should produce a long flame, and while there are other coals superior in this respect to Indiana coal they usually command a higher price and are not so conveniently available to the territory served by the Indiana mines. It is true that Indiana coal contains a somewhat high percentage of moisture, an adverse factor in the composition of a fuel, as the net loss in fuel value for each per cent of moisture is approximately twenty-two pounds of coal per ton. This, however, is a characteristic of many bituminous coals, and by no means confined to that from Indiana.

The thermal value of a coal as expressed in a certain number of B. T. U.'s per pound is, of course, of much importance in determining the value of any fuel. In determining the value of a coal for locomotive fuel, however, important as this factor may be, it is by no means the only important factor. Thus two different coals may analyze almost identical so far as moisture, volatile matter, fixed carbon, ash, and sulphur are concerned, and the value in B. T. U. content may be practically the same, and yet when the coal is burned in a locomotive firebox, particularly if the firebox temperature is high, one may be far superior to the other. The fusing temperature of the ash is one of the most important factors, and no matter what other high qualities the coal may have if the ash will fuse at a low temperature it is not a good coal for locomotive use. In fact it can not be used to advantage as a locomotive fuel even though the cost may be attractive, as the clinker, particularly the so-called soft clinker, is very detri-

